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Findings and Recommendations

In this chapter, the committee presents its findings and recommendations for addressing the aging avionics problem. The findings are presented first, beginning with general findings and proceeding to specific findings in the four categories discussed in Chapter 4: management issues, budgetary issues, technical issues, and business issues.

Because the Air Force is the sponsor of this study, the focus of the committee's recommendations is on actions that should be taken by the Air Force. However, during the data-gathering phase of this study, it became apparent that aging avionics is not just an Air Force problem and that all of the services could benefit from a DoD enterprise strategy for dealing with this problem. Therefore, the recommendations are divided into two groups, those that address only the Air Force and those that are applicable to all of the services and should be promoted by the Air Force for implementation at the OSD level. The committee attempted to distill the recommendations down to a few key items that are both important and achievable. There is no one-to-one correspondence between the findings and recommendations.

GENERAL FINDINGS

Finding 1. The problem of aging avionics in military aircraft is large and growing. Unless it is addressed proactively and comprehensively, it will have a significant negative impact on the military readiness of U.S. forces.

The Air Force alone estimates that it needs an additional $250 million to $275 million per year to address this problem, and the amount will certainly increase as the rate of obsolescence accelerates. As maintenance requirements and costs increase, fewer aircraft will be in a satisfactory state of readiness and/or mission capable, and less funding will be available for avionics upgrades, resulting in a self-feeding "death spiral."

Finding 2. The amount budgeted for the modernization of Air Force avionics systems is far short of the amount needed to pay for upgrades already approved in critical areas: performance and safety-mandated upgrades; avionics upgrades required for the global air traffic management (GATM) system; and replacements for aging avionics subsystems with the lowest reliability and/or highest repair costs.

The committee estimates that another $5 billion will be needed beyond FY05 just to complete the upgrades approved in the FY01 President's Budget Request, and these upgrades do not address the entire spectrum of avionics modernization.

Finding 3. A large number of organizations within DoD, the military services, and industry are attempting

to address various aspects of the aging avionics problem. However, these efforts are poorly coordinated and often duplicative.

The committee identified more than two dozen organizations in the Office of the Secretary of Defense, the military services, and industry that collectively spend tens of millions of dollars each year on technology development, software tools, manufacturing processes, circuit redesign and reengineering, and policy development to address the aging avionics problem. Although many of these programs are making substantial progress, they are poorly integrated. No enterprise-wide leadership is being provided.

Finding 4. Widespread application of a MOSA to avionics architectures would enable DoD to manage the aging avionics problem more affordably, for both new aircraft and many legacy systems.

Among the many organizations that testified before the committee, there was widespread agreement on this point, although there were diverse interpretations of what MOSA means.

Finding 5. Most of the benefits of MOSA can be realized through a "modular" approach. Although a fully "open" system would have some additional advantages to the government in a few situations (as they do in certain commercial sectors where quantities and related factors can support a viable business case for this approach), most DoD acquisitions cannot justify a totally open approach. The "modular" aspect of MOSA, however, could be applied to virtually all DoD products.

In theory, competition among suppliers in an open-systems approach could reduce government procurement costs. But business models must also be developed to provide incentives for suppliers to participate and to protect the intellectual property rights of avionics suppliers and their subtier sources.

SPECIFIC FINDINGS IN KEY ISSUE AREAS

Government Management Issues

Finding 6. There is no DoD-wide enterprise strategy, and only an embryonic Air Force-wide strategy, for dealing with the aging/obsolescent avionics problem. As a result, no enterprise management or leadership is addressing the problem on a full-time basis.

Partly because of "stove-pipe" management structures, organized around individual weapon systems,

management responsibility for dealing with the aging avionics problem is fragmented. The committee found little evidence of cross-program, cross-platform, or cross-service coordination in the Air Force.

Finding 7. The Joint Technical Architecture (JTA) for defining weapon system architectures and standards extends beyond those needed for *inter*platform interoperability. The extension into *intra*platform standards is neither consistent nor integrated with MOSA approaches for addressing aging avionics. In fact, the JTA has shown an alarming reversion to the Military Specification (Mil Spec) era by requiring an onerous number of standards and specifications for *intra*-platform avionics systems.

Finding 8. The technical expertise of DoD's depot support maintenance personnel in state-of-the-art avionics systems appears to be eroding as the workforce ages and retires.

DoD (as well as the defense industry) is having difficulty attracting highly trained young engineers, and many younger, high-potential personnel are leaving government service for industry, where pay scales are higher and opportunities for advancement are more abundant.

Finding 9. As modifications and upgrades of aging avionics systems continue, aircraft, even of the same type, are being equipped with avionics systems with different compositions, capabilities and compatibilities, thus exacerbating the configuration management problem.

Budgetary Issues

Finding 10. Long acquisition and upgrade cycles virtually require that avionics technology-refresh cycles be built into program plans during the engineering and manufacturing development phase prior to initial fielding.

Driven by the commercial market, component product cycles are becoming shorter and shorter, while military acquisition cycles are becoming longer as a result of funding constraints. This mismatch only exacerbates the obsolescence problem and drives up costs.

Finding 11. Because of legal restrictions on the use of appropriated funds in various segregated accounts ("colors of money"), program managers are unable to

address aging avionics problems in the most efficient way.

To ensure that appropriated funds are used for their intended purposes, Congress has placed a number of legal restrictions on budget accounts, including accounts available to address the aging avionics problem. Program managers spend a great deal of time trying to manage these color-of-money issues and often lack the budgetary flexibility to address problems logically as they arise.

Finding 12. A comprehensive MOSA solution to the aging avionics problem could save money in the long run but would generally cost more than customized point solutions in the short run. This is particularly true for avionics upgrades in the legacy fleet.

In the current budget-constrained environment, it is difficult to find funding for designs that would lead to reductions in TOCs in the long term.

Technical Issues

Finding 13. Implementation of MOSA would be facilitated by addressing the following needs:

- development of a common understanding of MOSA
- support for development of MOSA building codes, and disciplined design processes and related design tools required for MOSA implementation
- development of a test/requalification strategy coupled with the proper modeling and simulation tools to implement the MOSA strategy economically
- development of design-reuse databases and high-fidelity avionics models by original equipment manufacturers and suppliers

Business Issues

Finding 14. MOSA challenges the traditional military procurement model in several ways:

- With a modular, open-structured avionics system, DoD would, in theory, be able to solicit supplier competition at a variety of systems architecture levels: at the component level, the circuit-board level, the module level, or the subsystem level. The level must be high enough to provide incentives for qualified suppliers to participate, take advantage of local openness, and encourage suppliers to invest in research to improve avionics systems and stimulate innovation.
- The traditional mind-set of acquiring hardware and software will have to be changed to one of acquiring functionality (an approach in keeping with acquisition-reform precepts).
- The protection and value pricing of a supplier's intellectual property will be a key to success and will therefore require workable business models.
- Business incentives must be defined and provided to suppliers that will motivate a MOSA to avionics system design.

Traditionally, the government has acquired a hardware black box (with associated software) to perform a specific function. As signals processors have become more powerful general and digital signal processors, operations previously performed by hardware can now be performed via software algorithms, which are often embedded in the processors of another supplier's black box. The shift toward increasing software content in avionics systems will require a paradigm shift from the procurement of hardware to the procurement of functionality and value.

As the avionics industry moves into the era of software-dominant components and object-oriented design, determining software component pedigrees and ownership will be increasingly difficult. Suppliers must be able to protect their investments in the development of software; at the same time, they must satisfy the government's need for software that is part of a MOSA solution.

Finding 15. As DoD relies more heavily on commercial off-the-shelf hardware and software in avionics systems—and less on Mil Spec components and DoD-unique software languages—the expertise and intellectual property necessary to develop and maintain these systems will increasingly reside in the private sector.

Although the maintenance of legacy avionics systems will continue to be done by personnel at government depots, responsibility for the maintenance of new systems will devolve increasingly onto contractors. Government and industry will have to work together to develop creative solutions that recognize technological realities while complying with government mandates.

RECOMMENDATIONS

The recommendations that follow are divided into in two sections: recommendations that should be implemented internally by the Air Force, and recommendations the Air Force should seek to have implemented externally by OSD to facilitate better management of the aging avionics problem for all of the services.

Recommendations Specific to the Air Force

Recommendation 1. The Air Force, in coordination with the Office of the Secretary of Defense, should develop an "enterprise strategy" for dealing with the aging avionics problem. As a central feature of this strategy, the Air Force should mandate the creation of platform management/upgrade road maps with defined funding requirements for each weapon-system program.

Using these road maps, the Air Force should plan a program and budget for periodic block upgrades of all relevant programs, combining modernization with the resolution of the problem of DMS and the application of evolutionary acquisition principles. Comprehensive road maps to guide individual platform activities would also provide an effective framework for cross-platform and, eventually, cross-service coordination.

Recommendation 2. The Air Force should raise the awareness in Congress about the shortfall in funding for avionics modernization by increasing its congressional budget request to a level consistent with the modernization plans in system road maps.

Program Objective Memorandums should include funding plans for executing program road maps, as described above. Addressing this shortfall will require an increase in appropriations, not just reprogramming of existing funds. Anticipated TOC savings and derived payback periods should be included in the memorandums.

Recommendation 3. The Air Force should require a modular, open-system design strategy for all new programs and upgrades, unless specifically waived. Emphasis should be on achieving the benefits of modularity rather than on complete openness, which often creates business or technical problems. A training program in MOSA concepts should be included for program managers, acquisition personnel, and support personnel. Contractors should be encouraged to use executable specifications as the primary archival documentation of the system; these specifications should be integrated into the avionics design environment.

Recommendation 4. The Air Force should continue to use the Quarterly Acquisition Program Reviews (QAPRs) as a forum for top-level oversight and, most important, for setting priorities to address the aging avionics problem.

Each service has its own management processes for making budgetary decisions and overseeing programs. In the Air Force, QAPRs have previously been used for evaluating the potential of modular open avionics designs to reduce avionics costs.

Recommendation 5. The Air Force software and hardware testing community should develop a testing/requalification strategy tailored to modular avionics systems and should explore methods, including the use of high-fidelity simulation/emulation models and test beds, to minimize the impact on cost and schedule of requalifying avionics components and systems. The Air Force should build on the test strategy and simulation/emulation/diagnostic software model used by the Federal Aviation Administration in the commercial sector, which recognizes the value of reusing hardware/software and provides certification-test credit for reusable modules.

Operational testing and requalification costs and schedules are a major impediment to the smooth incorporation of block changes, especially in legacy equipment. Safety changes should be separated from other types of changes, and detailed emulation and simulation models should be used to minimize actual testing, especially in nonsafety areas. Contractors responsible for executing the changes should be contractually responsible for providing (or making available results from) emulation/simulation models and test histories.

To reduce further the cost/schedule of the testing/requalification process, the Air Force could include funding for the development of related modeling/simulation technology for reducing the need for verification/certification testing in its science and technology budget.

Recommendation 6. The Air Force should examine the feasibility of requiring, as a normal contractual deliverable, contractor-retained high-fidelity avionics

simulation models as a means of minimizing validation/certification testing.

Recommendation 7. The Air Force should increase its support for the new Aging Aircraft System Program Office (SPO), in the Aeronautical Systems Center (ASC), by reinforcing its leadership and management responsibility for reducing the total ownership costs of new and legacy avionics systems.

The new Aging Aircraft SPO could become the starting point of an Air Force-wide enterprise strategy for addressing the aging avionics problem. The effectiveness of the Aging Aircraft SPO will depend on how well it is funded and how much support it receives from Air Force leadership.

Recommendation 8. The Air Force should develop and apply innovative contracting approaches that provide incentives for both government and contractors to reduce total ownership costs of avionics systems.

For example, industry could be given complete responsibility for system support (including problems related to diminishing manufacturing sources/out-of-production parts) as part of the initial procurement of a new system or legacy upgrade. Multiyear support contracts could have a similar effect. To stimulate savings in legacy systems, contracting methods that share savings resulting from the introduction of MOSA designs and newer, more reliable technology would be a powerful tool for addressing aging issues. Innovative contract arrangements for government facilities and personnel could be used to ensure compliance with the 50/50 rule.

Recommendations That Apply to All of the Services

Recommendation 9. The Air Force should recommend that the Office of the Secretary of Defense develop an overall "enterprise strategy" for dealing with the aging avionics problem and issue a specific policy directive covering the following four points:

- A modular, open-system design strategy should be required for all new programs and upgrades, unless specifically waived.
- Development and use of program road maps should be mandatory for all Acquisition Category I (ACAT-I) programs (and their use encouraged for lesser programs); road maps should include

funding plans and anticipated reductions in total ownership costs.
- Reviews by the Defense Acquisition Board (DAB) of these items should be a required acquisition milestone exit criteria.
- A revolving fund should be established (possibly the Working Capital Fund) to further front-end design/qualification of MOSA-compatible solutions to the problem of diminishing manufacturing sources.

The MOSA requirement would be analogous to a similar situation in 1994 when the Deputy Secretary of Defense mandated that military specifications be eliminated, unless specifically waived. This resulted in rapid changes in acquisition practices. A similar cultural change could take place with the rapid adaptation of the modular approach in many DoD programs. Administrative procedures that worked well in the past should be used here.

The extent of the road map requirement should be determined after a more detailed review by OSD, but the Air Force has already made an excellent start in implementing road maps. An extension of this process could be applied to all DoD Acquisition Category I (ACAT-I) programs, unless specifically waived, and used for lesser programs as appropriate.

OSD and service oversight will be necessary to ensure adherence to the policy directive, as well as to provide a forum for reviewing waiver requests. Application of MOSA, adherence to platform road maps, and specific reviews of savings should be explicit items in program reviews by the Overarching Integrated Product Team (OIPT) (and service equivalent) program reviews as well as criteria in DAB milestone decisions. Some or all aspects of these mandates might be made Key Performance Parameters (KPPs) or exit criteria for acquisition decision milestones.

In FY00, the Air Force established a parts-obsolescence funding line as part of the Working Capital Fund overhead. However, this line item is relatively small, and additional funding approaches should be considered.

Recommendation 10. The Air Force should recommend that OSD form joint working groups with industry to address policy and business concerns involved in the resolution of aging avionics problems:

- An industry/government steering group should be formed as a focal point for addressing the issues raised by MOSA procurement models and related modifications to the acquisition process, business/competitive models, intellectual property rights, management/pricing, the 50/50 rule, and related issues.
- The role of the Software Engineering Institute (SEI) could be expanded to include the development of MOSA building codes and design tools and processes; SEI could also recommend the process for defining and implementing interface standards at the proper point in the design cycle. The committee believes these changes would be consistent with current plans to reorganize SEI to consolidate software development, system development, and integrated product team (IPT) activities.
- Congress should be encouraged to give DoD managers greater flexibility to shift funds among budget categories to take advantage of opportunities to reduce total ownership costs (TOCs).
- DoD should consider avenues to encourage young people to seek engineering educations focused on embedded software intensive systems and the maintenance of legacy systems.

Resolving aging avionics issues will require close interaction between government and industry, perhaps through established industry associations as a forum for industry to express its views and avoiding corporate conflicts of interest. Numerous examples of past successes are available (notably the National Center for Advanced Technologies Affordability Task Force on Acquisition Reform).

The growing role of software in modern aircraft avionics significantly contributes to rising TOC. Therefore, in addition to funding research to expand the technology envelope, resources must be found to support technology transfer and training for software developers.

Industry and industry associations can play a key role in encouraging Congress to work with OSD to adopt less restrictive constraints on color-of-money and related issues. DoD's adoption of contracting methods that provide greater incentives could encourage industry to become more proactive.

Recommendation 11. The Air Force should recommend that OSD form a joint cross-platform working group (JCWG) at the flag officer level to focus on reducing total ownership cost through the joint development of modular, scalable systems and the use of common solutions across weapon system platforms.

Many systems and subsystems used by different services are faced with the problem of obsolescence. Substantial benefits to all of the services could be derived from the joint development and adoption of common solutions. The end items might not be identical but could be tailored to meet service-unique requirements through the MOSA process, as long as they were derived from a common, modular, scalable avionics family. The JCWG could be organized along the lines of the Joint Aeronautical Commanders Group to leverage common solutions to common problems.

Recommendation 12. The Air Force should recommend that OSD examine and modify traditional defense procurement practices to minimize problems for avionics suppliers.

Significant business problems will arise for avionics suppliers as digital/software-intensive systems replace older systems. Many of these issues will revolve around the ability of suppliers to recover their investments (and make profit) in intellectual property. The profit model currently used would have to be revised to ensure that suppliers would realize a fair return on their investment. OSD should work with industry to explore these issues and modify its procurement practices, as appropriate. For example, intellectual property rights could be retained by suppliers, who would be compensated for their use through value pricing.

Recommendation 13. The Air Force should recommend that the current Open Systems Joint Task Force become the center of expertise and the focal point for addressing issues associated with the application of MOSA. Modularity, rather than total openness, should be emphasized to accommodate current business and technical issues.

Funding for the Open Systems Joint Task Force should be increased to promote the objectives of a MOSA strategy. Staff for the task force may also have to be increased. To clarify that the "modular" aspects of MOSA should be the primary objective, and to

minimize confusion associated with the term "open," the name of the task force could be modified to the Modular Open Systems Joint Task Force.

Recommendation 14. The Air Force should recommend that the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics restrict applicability of the Joint Technical Architecture (JTA) and mandated standards to *inter*platform inter-

operability and allow the *intra*platform standards to be defined by a MOSA approach, along with a greatly reduced number of mandated standards.

Although JTA's promulgation of standards for the interoperability between various platforms is important, in the committee's view, a MOSA strategy for avionics design for a given platform should be based on consensus standards derived from discussions involving both government and industry.